REMR Technical Note HY-N-1.8

CHANNEL MAINTENANCE: GUIDELINES FOR DIKE SPACING

PURPOSE: To present design steps for lateral dike spacing for use within an overall dike-planning and design process. Guidelines are based on flume test data and apply to lateral dikes constructed for maintenance of a navigation channel.

APPLICABILITY: While the design procedures included herein were developed for estuarine applications, they can be applied to any waterway where lateral dike construction is considered.

DIKE SPACING RESEARCH: Research was conducted to investigate the relationships between some of the dike design variables. This study resulted in a framework that relates a selected dike spacing and number of dikes to energy losses. Minimizing energy loss for a particular channel velocity generally indicates a good design in terms of maintenance. Dike field energy losses are included to produce a reasonable estimate of postproject channel velocity and water level.

The spacing guidelines described in this technical note were developed from limited laboratory flume tests. The flume facility dimensions did not relate to a particular prototype but were designed to mimic natural conditions with high Reynolds numbers and fully turbulent flow. Tests were designed to investigate velocity and head loss over a range of dike-spacing to dike-length ratios.

In order to generate a spacing guidance framework, a relationship between energy loss and dike-spacing ratios was developed. Energy loss in the flume test section was based on centerline data collected upstream and downstream of the test section. Energy loss was calculated from the differences of the sums of elevation and velocity heads at the upstream and downstream data collection points. A high energy loss indicates a less uniform flow field. A better flow distribution, in which channel velocity maintains a uniformly high level, is indicated by a lower energy loss for a particular dike spacing. Figure 1 relates the energy loss coefficient, k, to the number of dikes present for the flume tests conducted. The spacing ratio, S, is also indicated on Figure 1. The figure refers to the "total k," or the energy loss coefficient for the entire dike field.

A suggested optimum range of spacing ratios is shown in Figure 1. This spacing range corresponds to the energy loss coefficients for the number of dikes between the spacing ratios of 2.5:1 and 5:1. Figure 1 shows that a rapid decrease in energy loss is observed from the highest spacing ratios tested down to the 5:1 ratio, and energy loss becomes minimal with spacings closer than the 2.5:1 ratio. Surface-current patterns indicated uniform velocity flow fields over this range of spacings.

DIKE SPACING DESIGN EQUATION: Reducing the area of an estuarine channel may change the tidal range along with any desired increase in velocities. Designing lateral dikes for estuarine channels requires modeling each individual training-works plan to determine resulting velocities in conjunction with tides. Secondary considerations may include the effects of changing water levels and durations at respective levels. Details associated with applying numerical model solutions to estuarine training structure designs are beyond the scope of this technical note; but a range of ratios based on Figure 2 can establish a basis for modeling efforts. Figure 2 is a smooth exponential curve of k versus dike spacing ratio, S. The total energy loss for the entire dike field can be derived from this figure and by using the following equation for an estuarine situation:

$$k_t = k + k(S)\ (\text{no. dikes} - 1)$$

where k_t = total energy loss
k = energy loss for 1 dike = 1.5
$k(S)$ = energy loss associated with a given spacing ratio (Figure 2)

SPACING DESIGN FRAMEWORK: To use the total-loss equation for designing estuarine dike field spacing, follow these steps:

Step 1. Estimate the necessary velocity history required to maintain the channel. This velocity should be equivalent to any self-maintaining reach within the project or be designed to exceed the sediment transport threshold for the dominant class of sediment.

Step 2. Choose a dike spacing ratio between 2.5 and 5 (Figure 1). (This step is based on existing dike fields, designer experience, or judgment.)

Step 3. Estimate the dike length sufficient to reduce the channel area and provide the velocity selected in Step 1.

Step 4. Determine the number of dikes and adjusted spacing: Multiply the spacing ratio (Step 2) by dike length (Step 3) to determine the actual spacing. Then divide project-reach length by the spacing to determine the number of dikes. Round off to the nearest whole-dike value and adjust spacing accordingly.

Step 5. Read the value of $k(S)$ per dike for this spacing from Figure 2.

Step 6. Calculate the total energy loss coefficient k_t for the dike field from the "Total Energy Loss" equation.

Step 7. Run a one-dimensional unsteady flow model over an appropriate time (tidal cycles) using the coefficient k_t as an expansion or contraction energy loss coefficient (not both).

Step 8. Compare the model results from Step 7 with the required velocities from Step 1. If results are inadequate, modify length and repeat Steps 3 through 8 until necessary velocities are obtained.

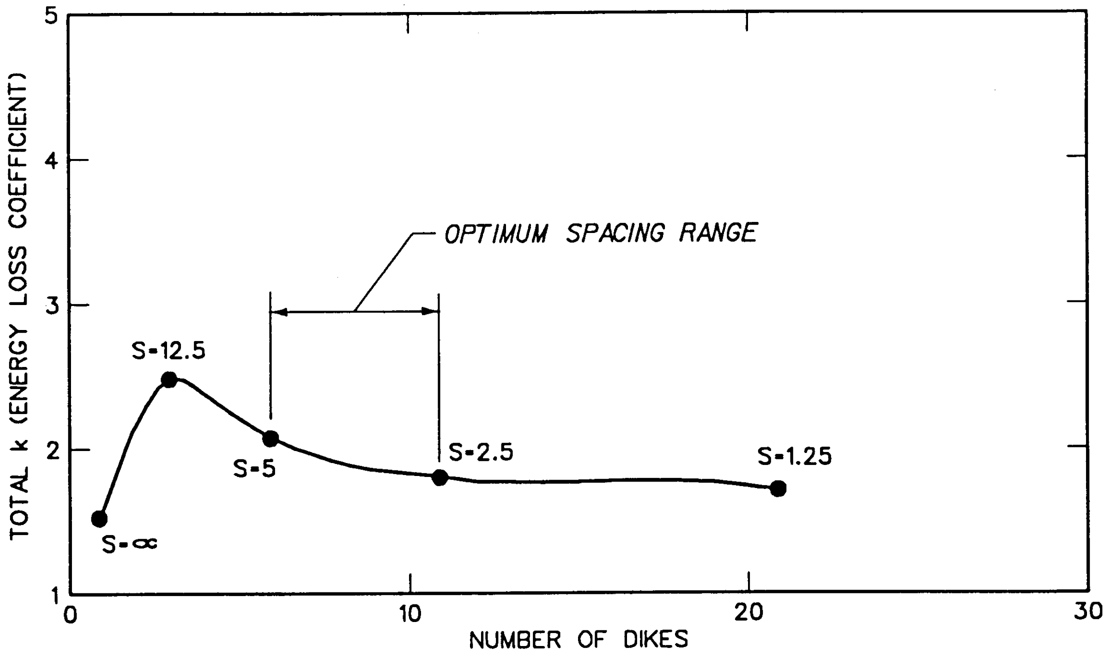

Figure 1. Total k versus number of dikes

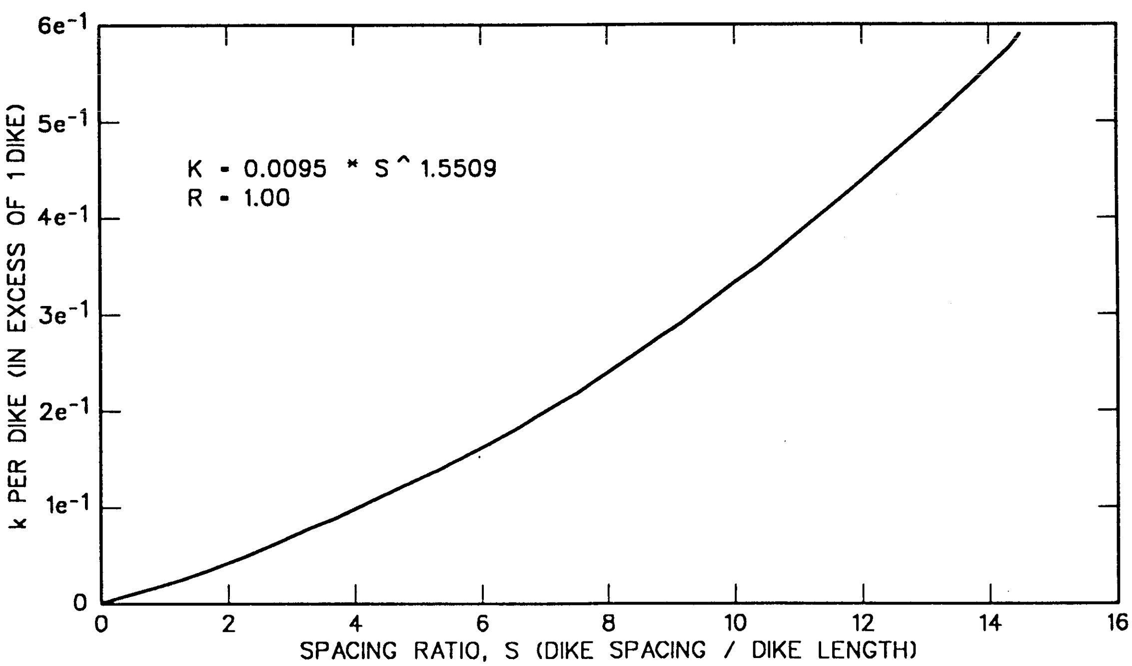

Figure 2. Energy loss per dike versus spacing ratio, S

CONCERNS: Above- and below-project design water levels and/or changes in duration of water levels may result from the energy loss associated with dike fields. Investigating these effects is necessary to evaluate material deposition and other effects outside the project area. These situations should be considered during the design process so that they can be included within the overall maintenance plan.

APPLICATION TO NONTIDAL WATERWAYS: The energy-loss equation can be used to determine resulting velocities in a riverine or otherwise nontidal channel. Although modeling may be required to evaluate overall project performance, velocities in conjunction with a dike project can be verified by following the framework presented above without running a one-dimensional model. Omit Step 7 and calculate velocity based on the dike field energy loss using k_t. Repeat this process until the required velocity from Step 1 is obtained.

RECOMMENDATIONS: The lateral dike-spacing guidance presented here merges with the design process after a significant portion of the project design has been completed. Design experience and physical and/or numerical modeling are important tools for evaluating a maintenance-type dike design. The design steps presented here are recommended to serve as a framework for evaluating lateral dike spacing. Subsequent modeling prior to final design is recommended.

REFERENCE: Alexander, M. P., and Berger, R. C. "Design Criteria for Lateral Dikes in Estuaries," REMR Technical Report in preparation. US Army Engineer Waterways Experiment Station, Vicksburg, MS.